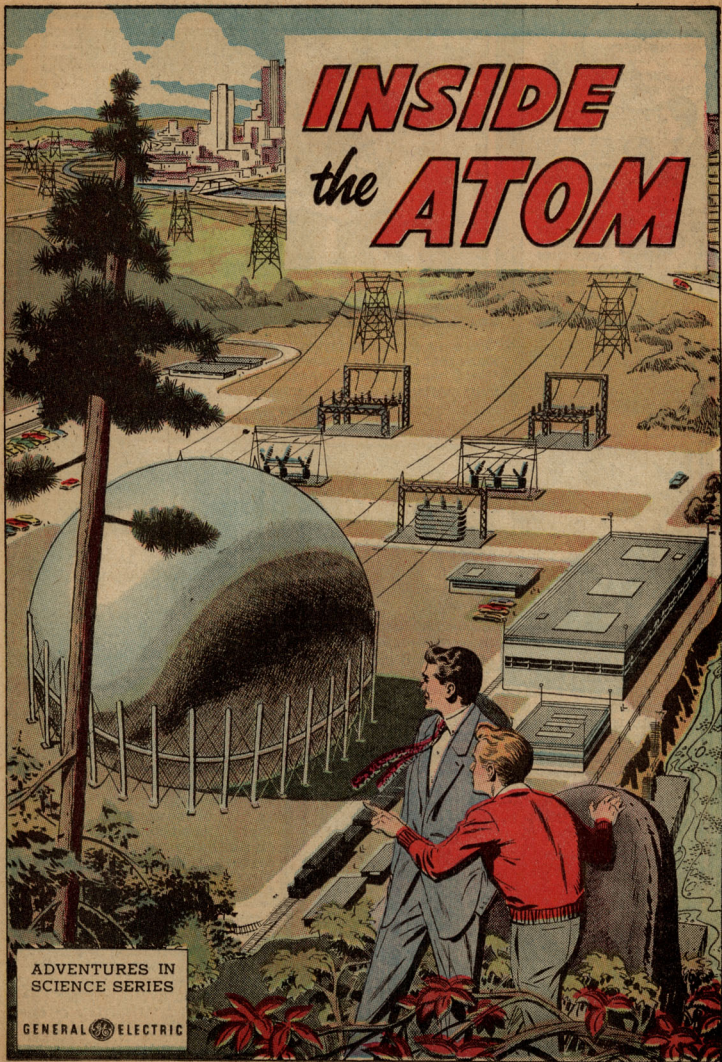


# ***INSIDE*** *the* **ATOM**



ADVENTURES IN  
SCIENCE SERIES

GENERAL  ELECTRIC





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THE ATOMIC ENERGY EXHIBIT BEGINS HERE, JOHNNY-- WITH A LOOK INTO THE PAST...



THE MODERN MIRACLE OF ATOMIC POWER IS THE CLIMAX OF A NEVER-ENDING SEARCH FOR KNOWLEDGE. IT ALL BEGAN MORE THAN 2000 YEARS AGO IN ANCIENT GREECE...



"You are a fool, Democritus! See you this bracelet... All men know that this gold is **one solid piece**." And Democritus answered: "No. I believe that **all matter**--even gold--is made up of tiny particles we cannot see."



"Mind not those doubters, master--tell me more." And Democritus said: "All things around us--trees and stones and even our own bodies--are made of 'building blocks'--so small that their size cannot be diminished. I, therefore, call them '**atoms**'\*..."

\* (from the Greek word "indivisible")



Aristotle, a few years later, added an idea of his own: "It must be that all the thousands of things on earth are combinations of certain basic '**elements**'--earth, air, fire, water..."



In the centuries that followed, men called "alchemists" struggled to find the combination of elements which would make precious gold. Kings offered kingdoms for the magic formula; but neither the knowledge nor wizardry of the greatest alchemists could duplicate Nature's richest secret...

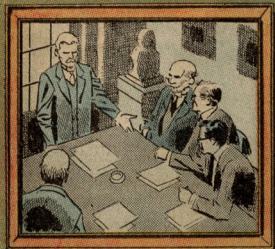


Then in 1808, a Quaker school teacher, John Dalton, suggested: "With all our knowledge of chemistry, we cannot change other elements into gold, because--



"Gold is itself a basic element -and each element is composed of its own special kind of atoms, different from the atoms of all other elements."

BETWEEN 1850 AND 1900, SCIENTISTS TRIED TO "EXPLORE" INSIDE THE ATOM...



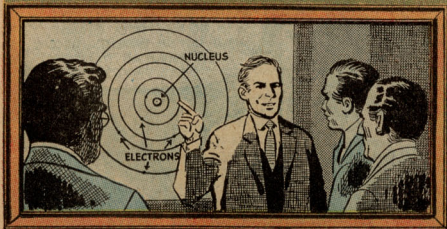
"Perhaps the atom, which we have thought the smallest possible particle, is itself made up of parts!"



"...and these parts are held together by electrical attraction."



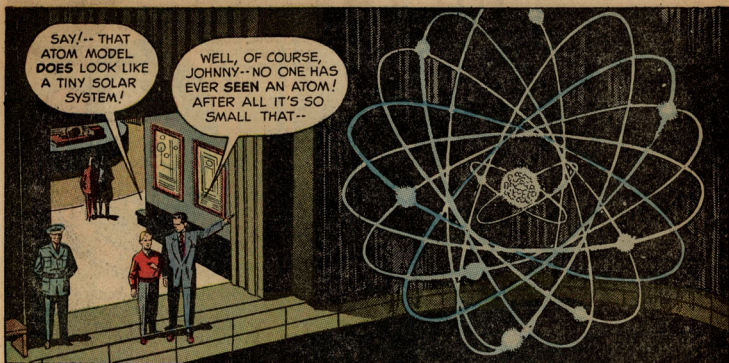
"If the atom is made up of parts, there must be spaces between them!"



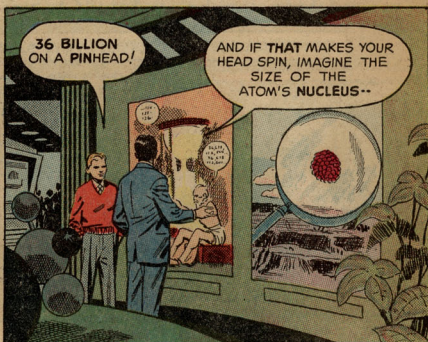
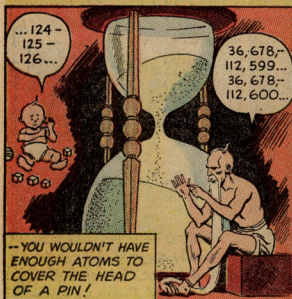
And, in 1913, Niels Bohr, a Danish scientist, combined these theories: 'An atom is like a miniature solar system -electron 'planets' whirling around a nucleus 'sun'..."



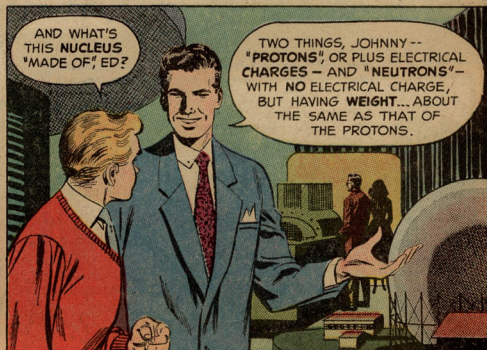
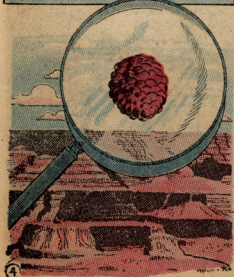




IF YOU COULD COUNT ATOMS FROM THE YEAR ONE UNTIL TODAY...



THE NUCLEUS IS TEN THOUSAND TIMES SMALLER THAN THE ATOM ITSELF!-- THE SIZE OF A RASPBERRY IN THE GRAND CANYON!





"PROTONS" AND "NEUTRONS"... DOES EVERY ATOM -- OF ALL THE ELEMENTS -- HAVE THEM IN ITS NUCLEUS?

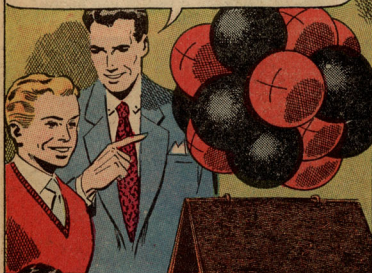
YES...AND I'LL EXPLAIN HOW, WITH SOME SIMPLE ARITHMETIC, THEY HELP TELL YOU TO WHICH ELEMENT AN ATOM BELONGS...

FIRST OF ALL, EACH OF THE 92 ELEMENTS IN NATURE IS GIVEN AN **ATOMIC NUMBER**-- THE SAME AS THE NUMBER OF **PROTONS** IN ITS ATOM'S NUCLEUS. NOW LET'S LOOK AT THIS MODEL OF A CERTAIN ELEMENT'S NUCLEUS...

THOSE RED "PLUS" BALLS ARE PROTONS-- THE BLACK ONES, NEUTRONS. NOW COUNT JUST THE PROTONS-- THEN CONSULT THE CHART AND TELL ME TO WHICH ELEMENT THIS NUCLEUS BELONGS!

--4-5-6-7...7 PROTONS. AND NUMBER 7 ON THE CHART IS--**NITROGEN**. SO THIS MUST BE A NITROGEN NUCLEUS!

BUT, ED, WHAT ABOUT THOSE "EXTRA-WEIGHT" BLACK BALLS-- THE NEUTRONS?



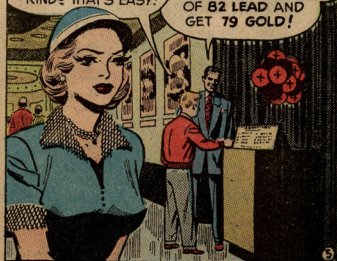
ADD THOSE TO THE NUMBER OF PROTONS--AND YOU HAVE THE ATOM'S WEIGHT--OR **MASS**...

YOU MEAN THAT IF I TOOK OUT SOME OF THOSE PLUSSES, IT WOULD CHANGE THE ATOM TO ANOTHER KIND? THAT'S EASY!

EASY, IS IT? REMEMBER, ALCHEMISTS WORKED FOR CENTURIES BUT COULDN'T TAKE THREE PLUSSES OUT OF 82 LEAD AND GET 79 GOLD!

## TYPICAL ATOMS

ELEMENT	PROTONS (ALSO ATOMIC NO.)		NEUTRONS		ATOMIC WEIGHT (OR MASS)
OXYGEN	8	+	8	=	16
IRON	26	+	30	=	56
GOLD	79	+	118	=	197
LEAD	82	+	125	=	207
URANIUM	92	+	146	=	238





**"BUT STRANGELY ENOUGH, SOME ELEMENTS CHANGE BY THEMSELVES! ANTOINE HENRI BECQUEREL FOUND ONE IN 1896..."**

MADAME CURIE, I CAN'T UNDERSTAND IT... THIS URANIUM ORE GIVES OFF SOME STRANGE KIND OF "RAY"!

PLEASE, PROFESSOR -- LET ME EXPERIMENT WITH IT.



BETWEEN THEM, THEY DISCOVERED THAT CERTAIN ELEMENTS ARE "RADIOACTIVE" -- THAT IS, THEY SHOOT OFF SOME OF THEIR PROTONS! HERE, I'LL SHOW YOU...



I GET IT-- IT'S SHOOTING OFF PLUS CHARGES!

EXACTLY! LET'S SUPPOSE THIS SPARKLER IS RADIOACTIVE--OR "HOT" URANIUM. YOU SEE, 92 URANIUM LOSES PLUS CHARGES UNTIL IT BECOMES 88 RADIUM--AND...

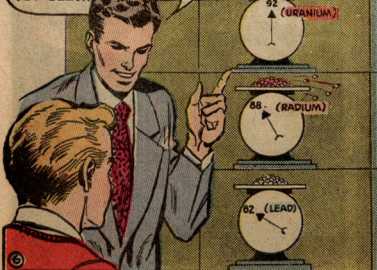


LOOK--THE SPARKLER STOPPED BURNING...

YES--AND AFTER CENTURIES, RADIOACTIVE ELEMENTS "BURN OUT" TOO. EACH 88 RADIUM LOSES PLUS CHARGES UNTIL IT FINALLY HAS BECOME 82 LEAD--A "COLD", OR STABLE ELEMENT.



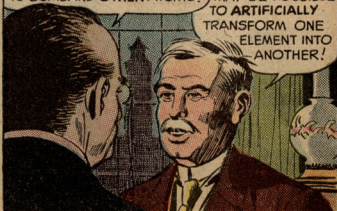
THIS WHOLE PROCESS IS CALLED "NATURAL TRANSMUTATION"... WHY IT HAPPENS, AND WHY IT STOPS, NO ONE KNOWS, BUT IT'S AN IMPORTANT PART OF OUR STORY, YOU SEE...



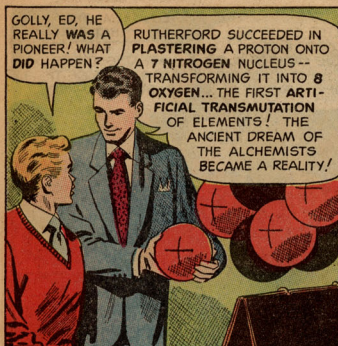
**"BACK IN 1919, AN ENGLISH SCIENTIST, SIR ERNEST RUTHERFORD--THE GREAT PIONEER IN ATOM-SMASHING--CONDUCTED SOME STARTLING EXPERIMENTS..."**

YOU MEAN, SIR ERNEST, YOU'RE USING THOSE POSITIVE RADIUM PARTICLES TO BOMBARD OTHER ATOMS?

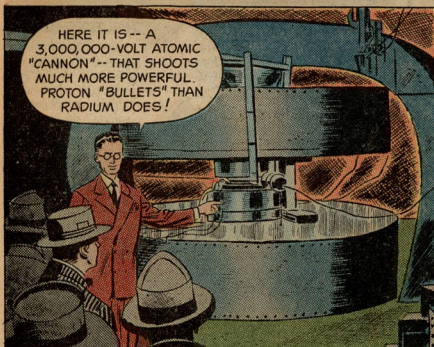
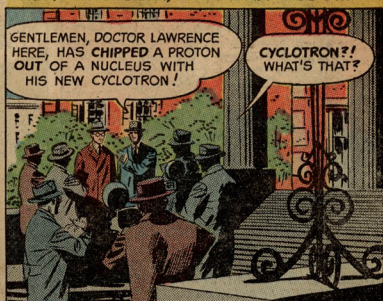
YES... AND WITH THESE PROTON "BULLETS", IT MAY BE POSSIBLE TO ARTIFICIALLY TRANSFORM ONE ELEMENT INTO ANOTHER!



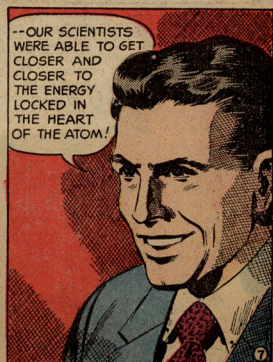
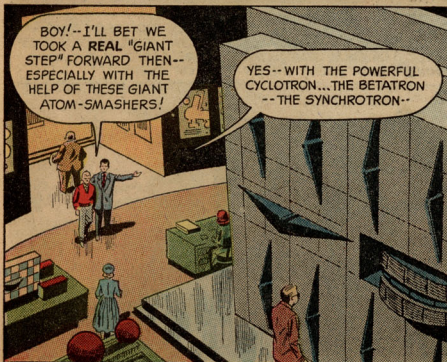
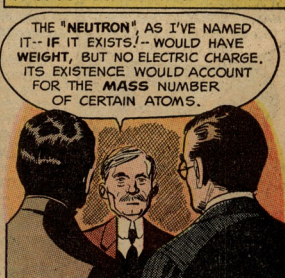




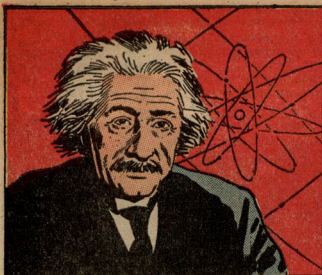
"RUTHERFORD'S EXPERIMENT STARTED A WAVE OF ATOM-SMASHING IN THE LABORATORIES OF THE WHOLE WORLD. IN CALIFORNIA, IN THE EARLY 1930'S..."



"THE ATOM-SMASHING EXPERIMENTS CONTINUED... AND SIR RUTHERFORD MADE ANOTHER IMPORTANT CONTRIBUTION TO OUR UNDERSTANDING OF THE ATOM..."







MEN HAVE ALWAYS USED ENERGY THAT CAME INDIRECTLY FROM THE SUN... BUT IN 1905, ALBERT EINSTEIN SAW, IN EVERY SPECK OF DUST HERE ON EARTH, A POSSIBLE SOURCE OF THAT SAME ENERGY...



"IF MATTER COULD BE DESTROYED, ENERGY WOULD BE CREATED IN ITS PLACE"... WHAT NONSENSE ALBERT WRITES!

NOT ONLY THAT-- BUT ACCORDING TO EINSTEIN'S THEORY--



-- IF YOU COULD DESTROY A TINY BIT OF MASS-- SAY, A POUND-- YOU'D GET THE SAME ENERGY AS THE BURNING OF ABOUT 2 MILLION TONS OF COAL!

"IN THE YEARS THAT FOLLOWED, THE SCIENTISTS' ATOMIC CANNONS CONTINUED TO FIRE AWAY AT THE ELEMENTS, IN THE ATTEMPT TO CHANGE -- TO CREATE NEW ELEMENTS. URANIUM-- THE HEAVIEST, THE LAST ELEMENT IN THE TABLE-- OFFERED THE BIGGEST CHALLENGE...

THEN CAME THE TURNING-POINT IN THE QUEST FOR ATOMIC ENERGY -- 1939: WHILE GERMAN PHYSICISTS, OTTO HAHN AND FRITZ STRASSMAN, WERE SHOOTING NEUTRONS AT URANIUM..."

RIDICULOUS!--AND ENOUGH OF ALBERT'S DAY-DREAMING... WE'VE GOT WORK TO DO!



WELL, DOCTOR, ALTHOUGH WE'VE FAILED TO CREATE A NEW ELEMENT, WE HAVE SUCCEEDED SOMEHOW IN PRODUCING ONE OF THE OLD ONES-- BARIUM!

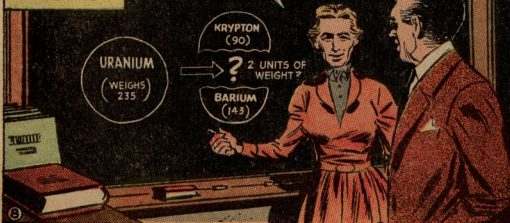
-- A MUCH LIGHTER ELEMENT, AT THAT! HMMM... I WISH DR. MEITNER WERE STILL HERE WORKING WITH US...

"IN DENMARK, DR. LISE MEITNER HEARD OF THE EXPERIMENTS -- DISCUSSED THEM WITH HER ASSOCIATE, DR. BOHR..."

THE BARIUM -- AND THE KRYPTON -- COULD ONLY HAVE BEEN PRODUCED BY THE URANIUM'S "FISSIONING" -- SPLITTING IN TWO -- WHEN IT WAS STRUCK BY THE NEUTRON!

BUT THOSE TWO HALVES WEIGH LESS THAN THE ORIGINAL URANIUM MASS! WHAT ABOUT THE DIFFERENCE-- THE MASS THAT'S MISSING? COULD IT MEAN--

"YES, PROFESSOR BOHR-- THAT IT MUST HAVE BEEN RELEASED IN THE FORM OF ENERGY!"





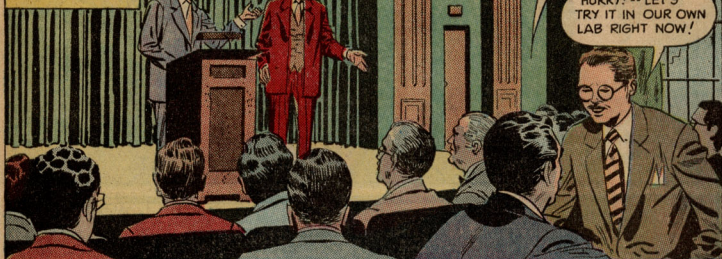
"WORKING ON DR. MEITNER'S CLUE, NIELS BOHR ORGANIZED FURTHER EXPERIMENTS BEFORE LEAVING FOR AMERICA. AND, A FEW WEEKS LATER, AT GEORGE WASHINGTON UNIVERSITY..."

-- THERE IS NOW PROOF THAT IN THE SPLITTING URANIUM, MASS IS DESTROYED-- AND ENERGY IS RELEASED! IS THAT CORRECT, DR. BOHR?"

YES-- AND WE ALSO HAVE REASON TO BELIEVE THAT IN THIS FISSIONING PROCESS, SEVERAL NEUTRONS ARE RELEASED!

DID YOU HEAR THAT? THAT MAY BE THE ANSWER TO THE 'CHAIN-REACTION' WE'VE BEEN LOOKING FOR!

HURRY!-- LET'S TRY IT IN OUR OWN LAB RIGHT NOW!

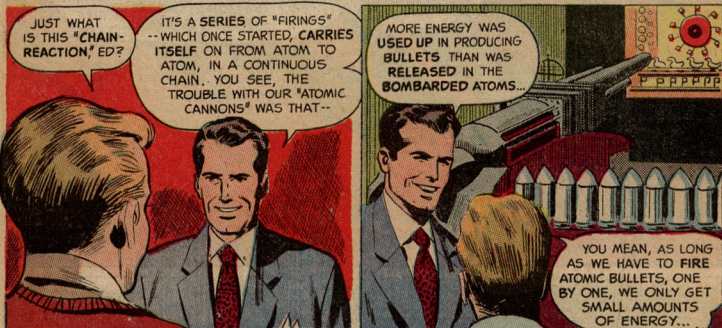


JUST WHAT IS THIS "CHAIN-REACTION", ED?

IT'S A SERIES OF "FISSIONS" -- WHICH ONCE STARTED, CARRIES ITSELF ON FROM ATOM TO ATOM, IN A CONTINUOUS CHAIN. YOU SEE, THE TROUBLE WITH OUR 'ATOMIC CANNONS' WAS THAT--

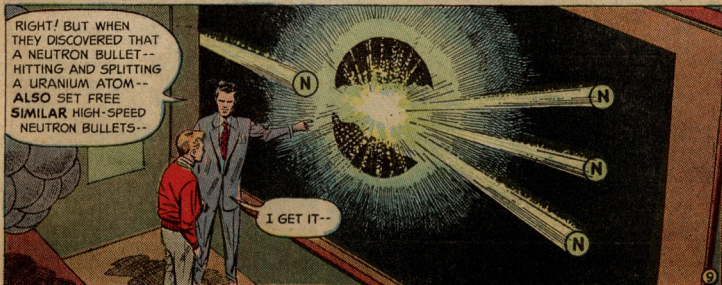
MORE ENERGY WAS USED UP IN PRODUCING BULLETS THAN WAS RELEASED IN THE BOMBARDED ATOMS...

YOU MEAN, AS LONG AS WE HAVE TO FIRE ATOMIC BULLETS, ONE BY ONE, WE ONLY GET SMALL AMOUNTS OF ENERGY...



RIGHT! BUT WHEN THEY DISCOVERED THAT A NEUTRON BULLET-- HITTING AND SPLITTING A URANIUM ATOM-- ALSO SET FREE SIMILAR HIGH-SPEED NEUTRON BULLETS--

I GET IT--





-- THEN THEY COULD USE THOSE NEW BULLETS TO SPLIT OTHER ATOMS... AND THEY'D GET THAT "CHAIN-REACTION"!

SMART BOY, JOHNNY! HERE, I'LL SHOW YOU HOW IT WORKS...

FIRST, WE'LL MAKE BELIEVE THESE MATCH-HEADS ARE URANIUM ATOMS. NOW, WE'LL ARRANGE THEM LIKE THIS -- SO THAT EACH ONE WILL LIGHT (OR SPLIT) TWO OTHERS...

LIGHTING THE FIRST MATCH STARTS A CONTROLLED CHAIN-REACTION. AND --

-- WITH URANIUM ATOMS, AFTER ONE SECOND, TWO MILLION SPLIT!...  $1/1000^{\text{th}}$  OF A SECOND LATER, 40 BILLION SPLIT! AND BEFORE YOU CAN BAT AN EYE, 900 TRILLION... AND FASTER, FASTER, FASTER...

"YOU CAN HARDLY IMAGINE THE POWER OF THE SUDDEN RELEASE OF ENERGY IN UNCONTROLLED CHAIN-REACTION..."

1 TBSP. OF URANIUM } SAME AMOUNT OF POTENTIAL ENERGY AS 750 TONS OF COAL!

WOW! THAT URANIUM REALLY "PACKS A WALLOP," DOESN'T IT?

NOT ALL URANIUM DOES, JOHNNY. YOU SEE, SCIENTISTS IN AMERICA DISCOVERED THAT, STRANGELY ENOUGH, ONLY A CERTAIN KIND OF URANIUM SPLIT...





"--ABOUT ONE OUT OF EVERY 140 COMMON URANIUM ATOMS HAS THREE LESS NEUTRONS. INSTEAD OF WEIGHING 238 AS MOST OF THEM DO, IT WEIGHS ONLY 235! U235 IS THE ONLY KIND THAT SPLITS!"

**COMMON  
URANIUM ATOM**

92 PROTONS  
146 NEUTRONS

238 WEIGHT

U238



**RARE  
URANIUM ATOM**

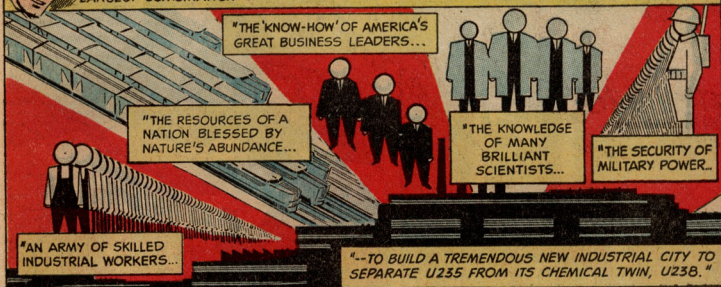
92 PROTONS  
143 NEUTRONS

235 WEIGHT

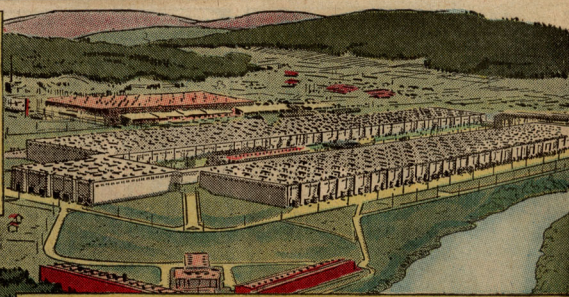
U235



AT FIRST, IT WAS ALMOST IMPOSSIBLE TO SEPARATE U-235 FROM U-238, BECAUSE BOTH ARE THE SAME ELEMENT. BUT THEN, IN 1940 THE UNITED STATES BROUGHT TOGETHER HISTORY'S LARGEST COMBINATION OF--

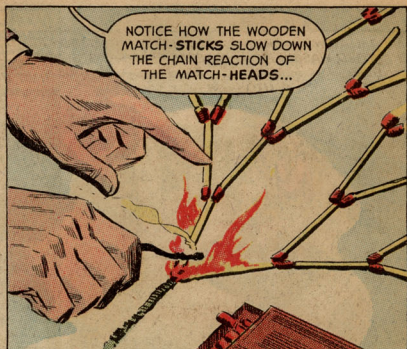
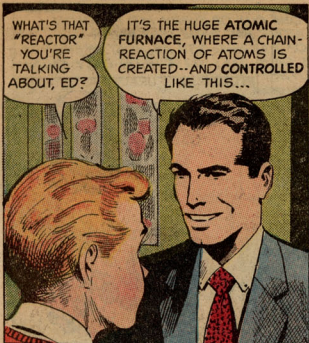


"JOHNNY, TEAM-WORK CAN DO ANYTHING! GENERAL ELECTRIC AND OTHER COMPANIES DID THEIR SHARE OF THE 'IMPOSSIBLE' BY BUILDING MANY SPECIAL KINDS OF ELECTRICAL EQUIPMENT IN RECORD-SMASHING TIME! AND SOON..."

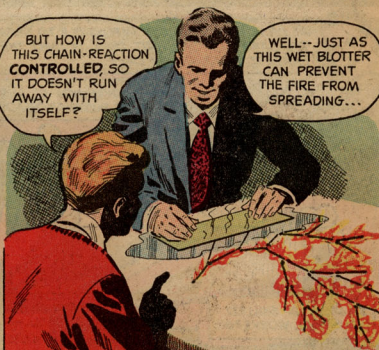
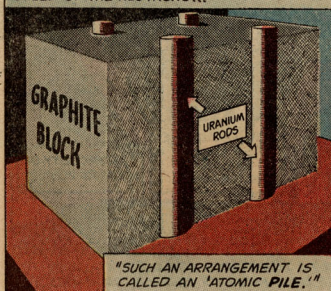


"IN THE MULTI-MILLION-DOLLAR PLANT AT OAK RIDGE, THE 'IMPOSSIBLE' WAS ACCOMPLISHED-- PURE U235 WAS SEPARATED FROM ITS TWIN, U238... AND WE HAD OBTAINED A NEW VALUABLE FUEL FOR REACTORS!"

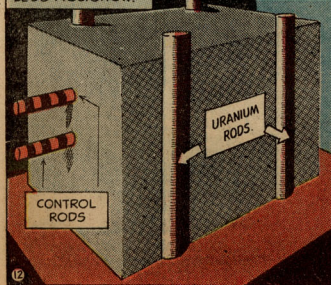




"IN A REACTOR, URANIUM RODS ARE SEPARATED FROM EACH OTHER BY 'MODERATOR' MATERIALS SUCH AS GRAPHITE--TO SLOW DOWN THE SPEED OF THE NEUTRONS..."

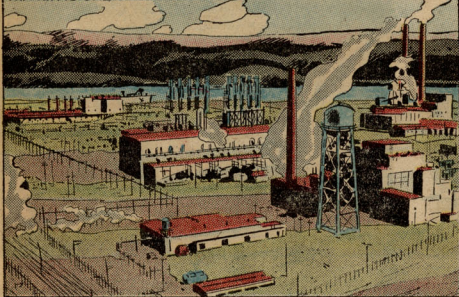


"...ADJUSTABLE CONTROL RODS IN THE REACTOR ABSORB SOME OF THE NEUTRON BULLETS. THE MORE 'BLOTTING' RODS, THE LESS FISSIONS..."



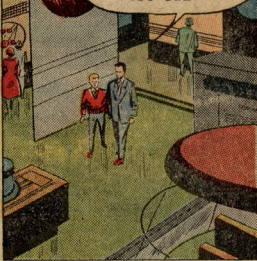


"AT THE ATOMIC ENERGY COMMISSION'S PRODUCTION FACILITY IN HANFORD, WASHINGTON, GENERAL ELECTRIC'S SCIENTIFIC AND ENGINEERING PERSONNEL ARE USING GIANT REACTORS TO MANUFACTURE PLUTONIUM--"

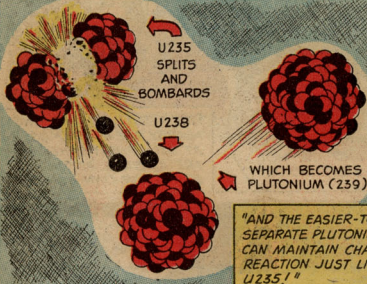


WHOA!  
-- WHAT'S  
PLUTONIUM?

A MAN-MADE ELEMENT  
PRODUCED FROM NAT-  
URAL URANIUM, TO  
WHICH EXTRA NEUTRONS  
HAVE BEEN PASTERED.  
YOU SEE --



"IN A REACTOR OF URANIUM, THE CHAIN-REACTION  
OF U235 CHANGES U238 ATOMS INTO PLUTONIUM..."

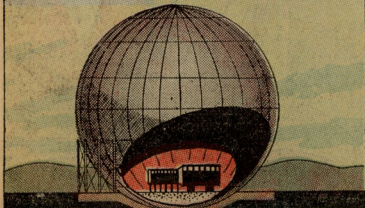


BUT,  
ED, WHAT  
ABOUT  
USEFUL  
ATOMIC  
POWER?

WELL, JOHNNY -- THE KNOX  
ATOMIC POWER LABORATORY,  
OPERATED BY G-E FOR THE  
ATOMIC ENERGY COMMISSION,  
STARTED WORK ON NUCLEAR  
POWER PLANTS IN 1946...  
WENT ON TO RESEARCH AND  
DEVELOPMENT OF **SUBMARINES**  
POWERED BY THE ATOM --

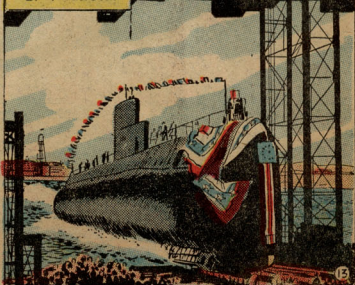


"AN ATOMIC POWER PLANT, SIMILAR TO THE ONE DE-  
SIGNER FOR THE U.S. NAVY'S SUBMARINE 'SEA  
WOLF', IS BEING TESTED IN THE WORLD'S LARGEST  
STEEL SPHERE -- AT WEST MILTON, N.Y."



"THE FIRST ATOMIC ELECTRICITY FOR HOME  
AND INDUSTRIAL USE HAS BEEN MADE AVAIL-  
ABLE FROM BY-PRODUCT ENERGY ASSOCIATED  
WITH THIS PROJECT."

"THE 'ATOM SUB', CAPABLE OF SPEEDS OF  
OVER 23 MILES AN HOUR, IS DESIGNED TO  
STAY SUBMERGED FOR THOUSANDS  
OF MILES..."

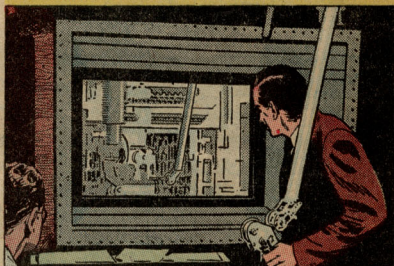




THE NEXT  
THING YOU  
KNOW, WE'LL  
HAVE AN  
ATOMIC PLANE!

--ONE THAT WILL BE  
CAPABLE OF CIRCLING  
THE GLOBE, USING  
LESS THAN A POUND  
OF FUEL! IT'S BEING  
DEVELOPED IN EVENDALE,  
OHIO--AMONG OTHER PLACES.

"MOST PRODUCTION PLANTS AND LABORATORIES  
HAVE EQUIPMENT TO HANDLE HIGHLY RADIOACTIVE  
MATERIALS FROM A DISTANCE--PROTECTION-OF-  
THE-WORKER ARE KEY WORDS IN ATOMIC ENERGY..."



"SAFETY IS ASSURED IN MANY WAYS..."

FINE! NOW YOU'LL HAVE  
IMPORTANT TRAINING  
BEFORE YOU'RE ALLOWED  
TO WORK IN THE PLANT.

ALL THESE RULES  
MUST BE OBEYED  
ALL THE TIME...  
NO EXCEPTION!

THESE SENSITIVE INSTRU-  
MENTS WOULD WARN YOU LONG  
BEFORE THE DANGER-POINT  
WAS REACHED.

YOU DON'T  
HAVE TO WORRY  
WITH THESE THICK,  
PROTECTIVE WALLS  
BETWEEN YOU  
AND THE "HOT  
STUFF" INSIDE!

"THE RESULT: FOLKS LIVING  
NEARBY ARE IN NO DANGER  
AT ALL... AND WORKERS  
ARE AS SAFE AS THEY'D  
BE IN THEIR OWN HOMES!"

GEE! I CAN'T HELP  
THINKING ABOUT ALL  
THE THINGS-  
TO-COME...

ATOMIC FLYING  
MACHINES ON  
MY BACK...

ATOMIC ROCKETS  
TO THE MOON...

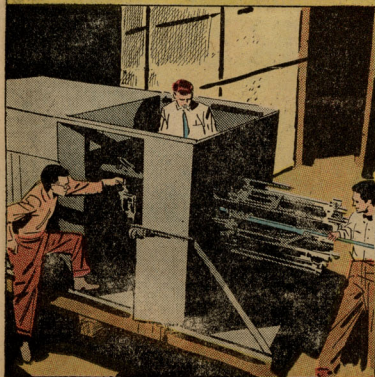
HOLD ON, JOHNNY!  
--YOU'VE BEEN READING  
TOO MANY COMICS!

ATOMIC "PILLS" TO RUN OUR CARS  
FOR YEARS AT A TIME!



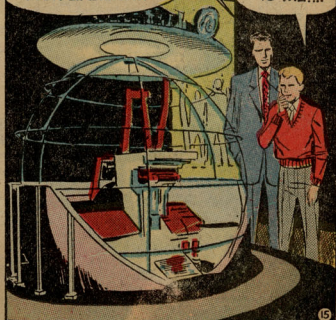


"NUCLEAR RESEARCH REACTORS ARE BECOMING VALUABLE RESEARCH TOOLS FOR AGRICULTURE... BIOLOGY... CHEMISTRY... AND MEDICINE..."



AND HERE, JOHNNY, IS A SIMPLE MODEL OF THE POWER PLANT OF THE FUTURE, WHICH WILL PROVIDE ATOMIC POWER FOR HOME AND INDUSTRY - DURING YOUR LIFETIME ...

"SIMPLE?!" IT LOOKS PRETTY COMPLICATED TO ME!...





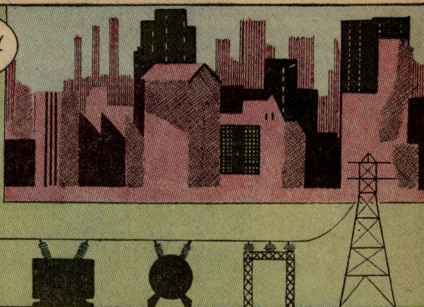


WELL, YOU KNOW, HARNESSING THE ATOM'S TREMENDOUS ENERGY ISN'T EXACTLY EASY! BUT TO PUT IT SIMPLY -- YOU SEE...

"HEAT IS PRODUCED IN THE REACTOR -- WHICH, WHEN COOLED BY WATER -- CHANGES THE WATER TO STEAM..."

"THIS STEAM DRIVES THE TURBINES THAT TURN THE GENERATORS (WHICH PRODUCE ELECTRIC POWER)..."

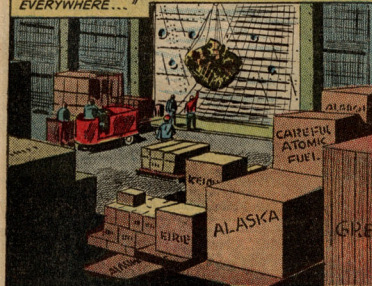
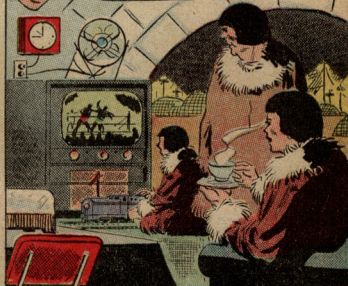
"THE ELECTRICITY IS THEN TRANSMITTED -- TO THE CITY, FOR HOME AND INDUSTRY."



"WHEN WE'VE SOLVED ALL THE PROBLEMS, THE ENERGY POTENTIAL LOCKED INSIDE THE ATOM WILL PROVIDE ENOUGH POWER FOR EVERYBODY -- EVERYWHERE..."



GOLLY, I CAN SEE IT ALL NOW --



YOU'RE A LUCKY FELLOW, JOHNNY, TO BE A "PART" OF TODAY... AND -- THERE'S A WONDERFUL FUTURE AHEAD! -- WITH ATOMIC ENERGY.

I KNEW IT, ED -- BUT AT LEAST NOW I UNDERSTAND IT A LOT BETTER!

GENERAL ELECTRIC





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